Detailed infrared spectra of refrigerant gases

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Climate change is a serious problem caused primarily by the use of fossil fuels, although greenhouse gas (GHG) emissions are also regarded as a major contributor. Globally, greenhouse gas emissions cause an increase in average temperature, a decrease in ice mass, which causes sea level rise, and extreme climate events. Surface temperature has risen by 1.4 °C since the 1900s, with an exceptional increase of 0.18 °C predicted for June 2023 (Rohde 2023).

Fluorinated greenhouse gases (FGGs) are categorized as global pollutants. Most fluorinated greenhouse gases have an extremely high global warming potential (GWP) when compared to other greenhouse gases (Hansen et al., 2010). Historically, chlorofluorocarbons (CFCs) have been utilized as propellants for packaging materials, aerosol solvents, and refrigerants, and they have been identified as potential contributors to ozone depletion (Wallington et al., 1994). The Montreal Protocol of 1987 agreed to eliminate the use of CFCs. This led to the replacement of CFCs with hydrofluorocarbons (HFCs) (Sheraz et al., 2021). As a result of recent changes in environmental legislation, new refrigerant categories have evolved, with the goal of making refrigerant gases "greener" in terms of their impact on the ozone layer.

It is critical to be able to detect the existence and concentration of these new gases, as well as older gases, in order to evaluate if the systems are operational and whether they can be recycled or destroyed. Additional reasons why quantitative measurements of the presence of such gases are required include: Leak detection during the manufacturing of air conditioning components to ensure that they are leak-free, as well as testing newer systems to ensure that they are running at maximum efficiency and mixing ratios.

Fast Fourier transform spectroscopy can be utilized for detection and quantification. However, detailed infrared spectra of currently used refrigerants are scarce or even not available in the literature. In the present work, we report on a detailed study on infrared spectroscopy of refrigerant gases. These were achieved utilizing an in-house 3D-printed tubular reactor with two BaF_2 windows, which can be integrated into the beamline of a Bruker IR-Spectrometer.

The data collecting process required exposing the IR-sensor to controlled gas environments containing refrigerant gases at various concentrations using precisely produced gas combinations. This was achieved by fixing two BaF_2 windows with 1 mm thickness and 8 mm diameter, on a tubular aluminum reactor who´s inner surface was polished in order to reflect the IR irradiation. The gases were directed through the reactor from gastight bags without any contamination with ambient air and thus with humidity that could influence the spectra. The obtained detailed IR-spectra can be used for the identification of characteristic peaks for each refrigerant and thus for their simple detection using IR-sensors.

In practical applications in a sensing device, a series of IR sensors is applied while the detection wavelength of each sensor can be fixed by application of an IR-window with certain wavelength in front of it. Finally, the sensors can be calibrated in order to provide precise and consistent measurements.

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